

**AUTONOMY OF ROVER OPERATIONS: USE OF AUTOPUL IN UPLINK PROCESSING.** M. H. Sims<sup>1</sup> ([Michael.Sims@nasa.gov](mailto:Michael.Sims@nasa.gov)), K. E. Herkenhoff<sup>2</sup>, and the Athena Science Team, NASA, Ames Research Center, Moffett Field, CA 94035, <sup>2</sup>U. S. Geological Survey, Flagstaff, AZ 86001

**Introduction:** The operation of a robotic device on a planetary surface (as for example, the operation of the Mars Exploration Rovers (MER)) can be viewed as the decisions of what operations to do and the encoding of those decisions into instructions which are uplinked to the robot. The work described here concerns the latter (i.e., the ‘uplink processing’) for the Microscopic Imager and Engineering camera instructions for the MER rovers.

**MER Camera Operations:** Although the time constraints and other specifics can vary greatly from mission to mission there is a commonality to the core of the uplink processing. In the case of MER there are typically (depending on orbital geometry constraints, time of day, etc.) between half a dozen and a dozen hours available for uplink processing prior to the actual uplink. Once the goals for that uplink are decided then the processing requires the a) generation of uplink commands for all commandable subsystems, b) integration of those commands into a unified plan, c) verification of that plan’s compliance with constraints (such as energy, thermal, etc.), d) verification of compliance with flight rules (such as ‘do not use this camera while using Direct to Earth communication’ or ‘this command requires mission managers approval to use’), e) approval to uplink via multiple reviews and review approvals, f) encapsulation of the plan into a form for communication and g) passing of that encapsulated plan to an uplink facility for uplink at specific times. In the case of MER each instrument (such as the Microscopic Imager) on each rover has a person designated as Payload Uplink Lead or PUL to do a) above and to participate in the remaining steps above. In the early days of the MER mission this was often complex, sometimes tedious and frequently led to long and difficult days for the PULs. In addition to the labor and time demands to accomplish this job it introduced the possibilities of errors because of overload, and simply because humans aren’t perfect processors and do make mistakes. Examples of those kinds of errors are reports and files put in the wrong places, incorrect dates entered, forgetting to deliver an instrument sequence, etc. One can imagine more serious errors as well. There are mechanisms to reveal some of these errors during the uplink process but that detection is not perfect and often depends on human eyes watching other humans and again is susceptible to natural human mistakes. The AutoPUL system was begun in the earliest days of MER as an approach to

easing the tedious and determinable portions of the uplink process for the Microscopic Imager and Engineering Camera PULs via autonomy. It was specifically designed to work within the constraints of the PUL uplink process as they existed at the time on MER. For example, all of the reporting and delivery systems inside of AutoPUL effectively automated many of the exact processes that an actual PUL would have done. That allowed for a natural, incremental introduction. As funding for MER operations was reduced during the extended missions, increased autonomy and the resulting reduction in person-hours required for daily operations became more important.

AutoPUL builds upon an existing set of tool such as RSVP, Engineering Library Sequences and sequence delivery scripts.

Specifically, AutoPUL does the following:

- parses preliminary plans for uplinks to determine plans for Microscopic Imager and Engineering Camera use
- allows user editing of which sequences will be delivered
- scripts and thereby delivers sequences for uplink
- generates a set of reports on all actions taken
- delivers those reports into the MER documentation system